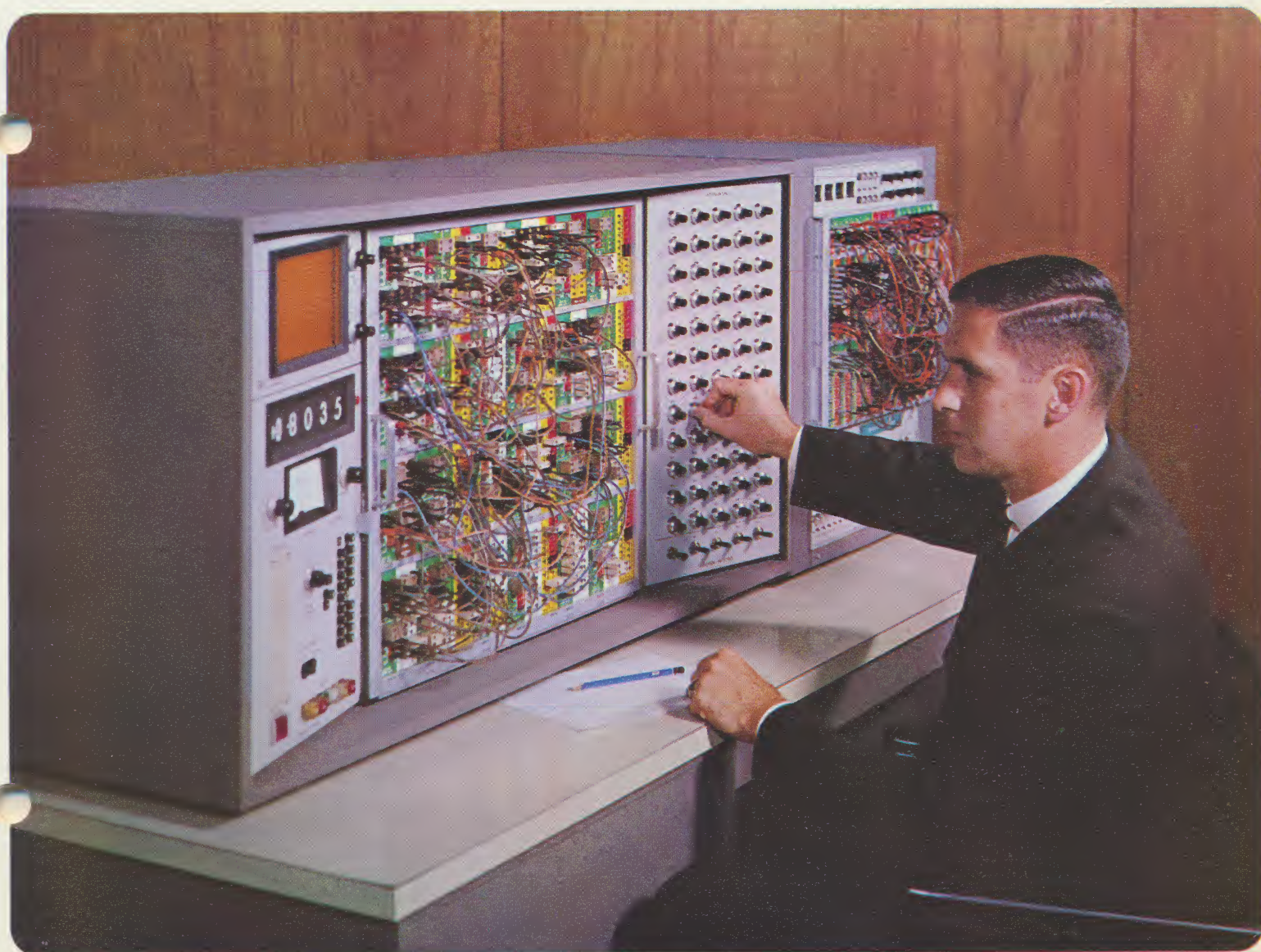


EAI[®]

TR-48/DES-30

DESK-TOP ANALOG/HYBRID COMPUTING SYSTEM

For the ultimate in high-speed, low-cost problem-solving capabilities



AREAS OF APPLICATION

Advanced Problem-Solving and Teaching of Computation Techniques in Universities and Technical Schools

Simulation of Physical System-Behavior for Classroom Demonstration

Simulation and Control in the Process Industry

Data Reduction and Physiological Model-Building in the Life Sciences Laboratory

System Simulation in the Aerospace Industry

5 STEPS TO THE SOLUTION OF YOUR RESEARCH AND ENGINEERING PROBLEMS . . .

Step 1 — Problem Analysis

Problem is translated into a mathematical description using algebraic and differential equations.



Step 2 — Programming

The information flow sheet is prepared using a block diagram to represent the various computer elements and their interconnections.



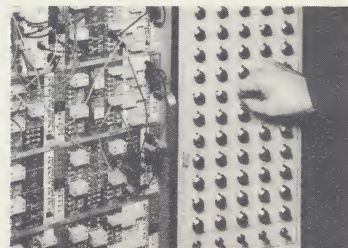
Step 3 — Patching

With the aid of this diagram patch cord and bottle plug connections are made between various computer components.



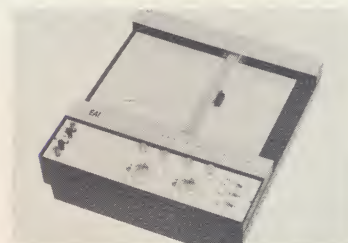
Step 4 — Insertion of Problem Parameters

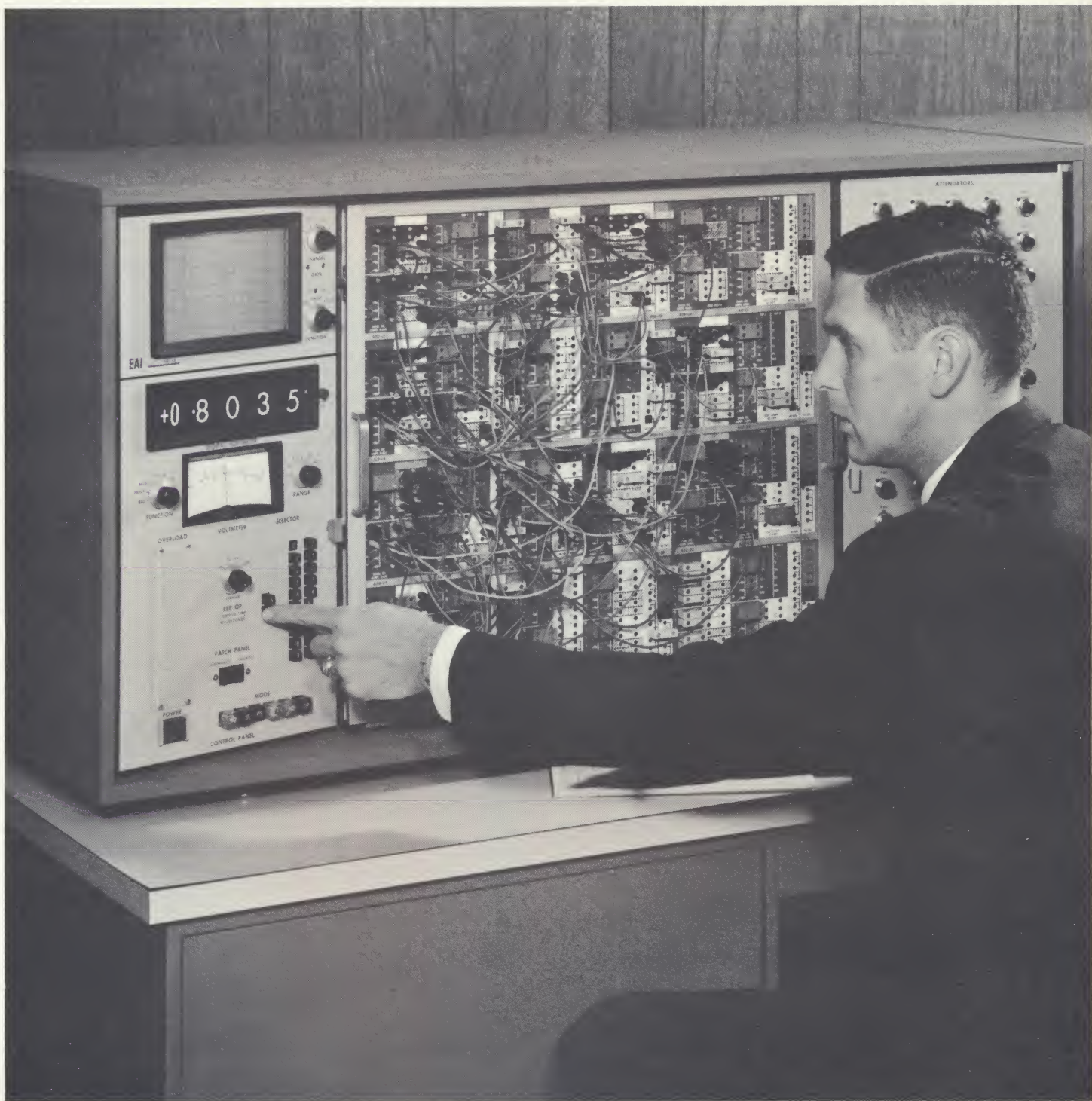
Coefficient setting potentiometers are adjusted to provide design parameter inputs.



Step 5 — Solution

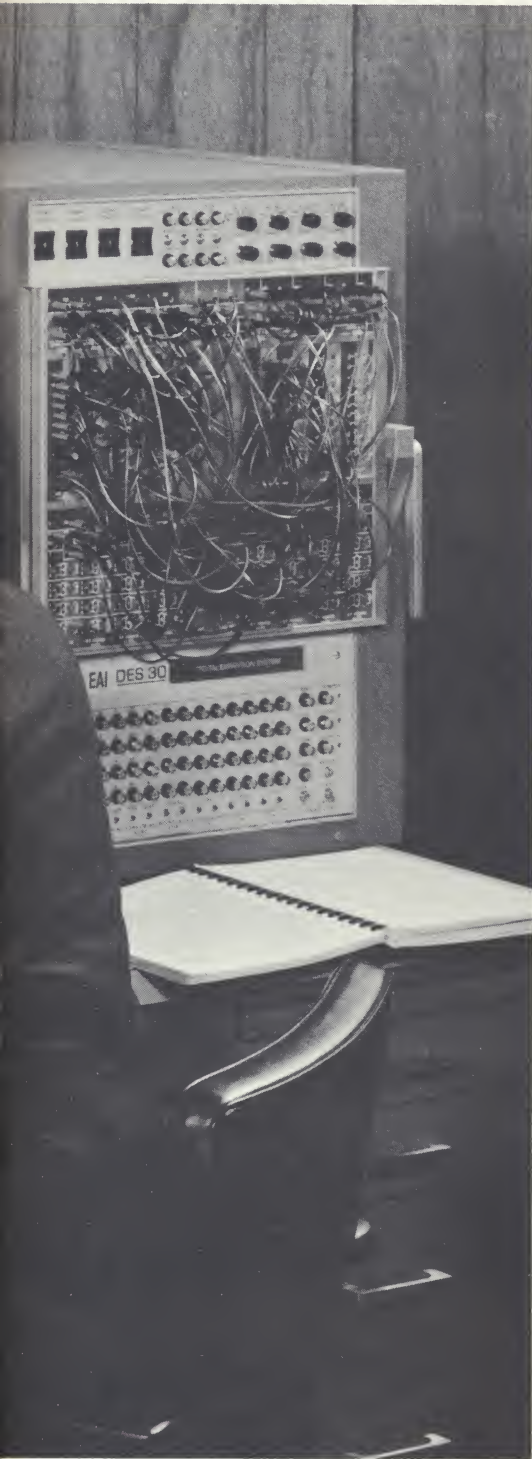
The computer solution is performed in the exact manner prescribed by the mathematical equations. Solutions are presented on an XY plotter.





The TR-48

TR-48 Computing System Characteristics



DES-30 Hybrid System is pictured above.

General

- ... 58 Amplifier Capacity
- ... Operator Oriented, Self-Contained Computing Center
- ... Compact and Mobile, Fits on Any Desk
- ... 10 Volt Reference for Reliability, Safety and Greatest Dynamic Performance
- ... Low Power Drain, Plugs into any 115/230 Volt, 50-60 cps Outlet. Power Drain is Less Than a 150 Watt Bulb.
- ... Modular Expansion Capability by Plug-In Components to the Fully-Wired Console
- ... All Solid-State System
- ... Hybrid Computing Capability Through Addition of the DES 30 Digital Expansion System

Computer Console

- ... Human-Engineered for Optimum Accessibility
- ... Relay or Electronic Mode Control
- ... High-Speed Repetitive Operation Capability — Automatic Time-Scale Change of 500 to 1 facilitates change from real time to HSRO
- ... Push-Button Select System for Readout of Potentiometers, Amplifiers, and Trunks
- ... Central Overload Indicator Panel
- ... Push-Button Mode Control

Computing Components

- ... Removable Pre-Patch Panel
- ... Each Computing Component in Compact, Removable Tray located directly behind the patch panel
- ... Amplifiers have 400 Kc bandwidth and No Velocity Limit to 96 Kc
- ... Flexible Integrators Permit Multi-speed Solutions and Offer Time Scales of 1:1, 1:10, 1:500, and 1:5000
- ... Electronic Comparators for Track and Store and Hybrid Operation
- ... Versatile Electronic Multiplier/Divider can Produce Square or Square Root of two Independent Input Variables
- ... Extensive Complement of Fixed Function Generators for Highest Accuracy and No Set-Up Time

Readout

- ... Integral Four-Channel Repetitive Operation Display
- ... XY Plotter Pen Lift From Mode Control or Logic Program
- ... All Solid-State Digital Voltmeter
- ... Termination of All Display Inputs on the Patch Panel Read-out Module



PACE[®] TR-48/DES-30

computing system combines experience proven design with increased problem solving capabilities

This new EAI computing system makes the benefits of analog/hybrid computation available to industrial, government, and university research and engineering groups; as well as undergraduate and graduate educators. Performing those mathematical operations required in the solution of most research and engineering problems, the TR-48/DES-30 expands your capabilities by offering

Analog and Hybrid Computing Capability start with a basic analog system and add the DES-30 Digital Expansion System at any time in the future for Hybrid operation.

An Economical Solution to Problems the incentive of faster development of lower cost processes and systems requiring minimum investment.

Excellent Man-Machine Communications the operator can easily change problem parameters and immediately observe the resulting changes in system response. He develops better insight into the dynamic performance of the physical system.

Direct Graphical Representation solutions may be displayed on oscilloscopes, XY recorders and/or strip chart recorders.

The compact, solid-state design of the TR-48 provides, for the first time, an analog computer large enough to solve problems typical of most engineering groups and which can be located right in the laboratory. No elaborate installation facility with a specially trained staff to operate it is required . . . no air conditioned room . . . no special power requirements — it can be powered from any ordinary electric outlet . . . yet because of its design simplicity and field proven dependability, no maintenance staff is required as would ordinarily be true for other computers with equal problem solving capabilities.

The TR-48 makes it convenient for the engineer with the problem to use the computer . . . the individual most familiar with the problem is present during the course of the simulation to make those design decisions that only he can make . . . thus maximum benefits from analog simulation are obtained. The engineer can experiment with new designs that formerly were too costly or time consuming to try. He can perfect the design and work out all the "bugs" right on the computer . . . before building pilots or prototypes, drastically reducing design time and costs.

This dependable new computational tool is completely solid-state for highest reliability and long trouble-free life. Its design carries with it the history of maintenance-free reliability of its famous companion, the PACE TR-20, the latest version of the first completely transistorized analog computer, the TR-10.

TR-48

quality engineered for simplicity, flexibility and maintenance-free operation

COMPUTER CONSOLE

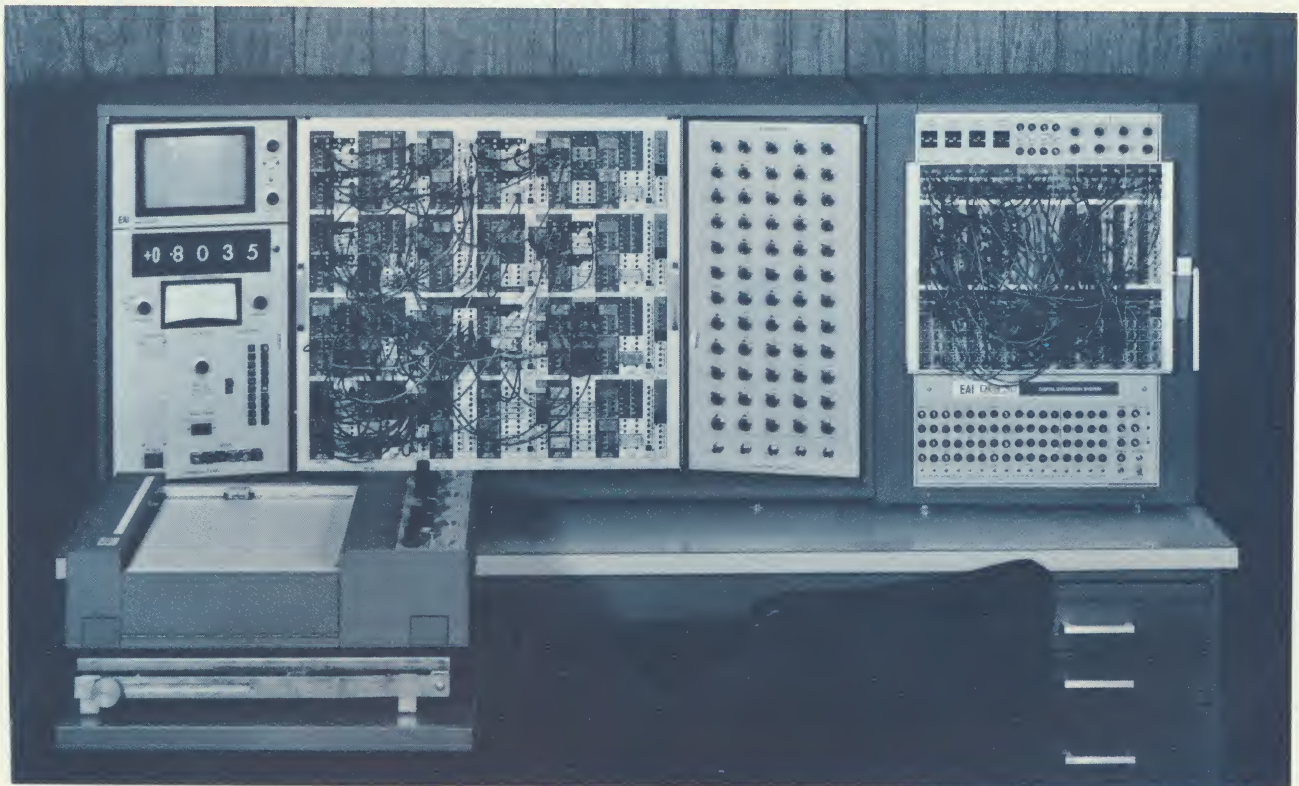
The console of the TR-48 System is a self-contained computing center with programming, control, and computing components all housed within a single desk-top, three-bay structure. It combines ease and flexibility of analog programming and digital logic capability with the addition of the DES-30 digital expansion system in a fourth bay at the right of the console. Detailed consideration has been given to human-engineering as an operator-oriented system, with emphasis placed on convenience and efficiency of operation.

The left bay houses the push-button mode and read-out selector system control panel, including the digital voltmeter and null-meter displays. It also includes the analog overload indicator panel, and the patch panel engage/disengage switch. The repetitive operation display scope is mounted at the top of the bay.

The center bay houses the flexible pre-patch panel. This removable panel can be patched and checked off the computer, thereby making most efficient use of actual computer time. Patched boards can be stored for future use.

The right bay contains the potentiometers and function switches. As with the left bay, these panels are mounted at an angle for easy visibility and control access for the operator.

The majority of computing elements are contained in removable trays located directly behind the program patch panels. Additional trays which house the variable diode function generators are located behind the potentiometer panel. This panel is a hinged-door, which opens to give access to the function generators. The trays slide out on rails permitting simple adjustment and function set-up. All controls and monitoring devices are located for greatest ease of manipulation and display by the computer operator.



TR-48

a control panel engineered to aid problem solutions

The Control Panel is the nerve center of the TR-48 Computer placing all controls for the complete operation of the computer in one convenient location. Human engineered panel design facilitates computer utilization and problem solution . . . provides means for controlling computer operation and metering of component output voltages. All knobs, push-buttons, and switches are clearly labeled for easy identification.

Relay or Electronic Mode Control. . . computer operating modes . . . POT SET, RESET, HOLD, OPERATE AND REPETITIVE OPERATION . . . are selected by means of push-button . . . each illuminated when energized, allowing the operator to determine at a glance the computer operating condition. Electronic Mode Control may be substituted for Relay Mode Control. This provides for the operation of integrator networks which incorporate solid-state switches in place of relays. EMC allows higher problem solution speeds and more flexible control of integrators from logic devices such as the DES-30 Digital Expansion System.

Output Selector . . . push-button switches allow the output voltage of all amplifiers, coefficient potentiometers, and input trunks to be monitored on the Digital Voltmeter or multi-range voltmeter. The Output Selector is also terminated on the patch board permitting outputs of interest to be monitored on external equipment.

Voltmeter . . . a precision, multi-range meter for the monitoring of amplifier outputs, input trunks and power supply voltages, and also used for the manual balancing of operational amplifiers. Five meter ranges are selected by rotary switch.

VM Selector Switch . . . selects power voltages or outputs selected by push-buttons for reading on voltmeter.

HSRO Control . . . permits the selection and adjustment of solution time for those TR-48's equipped with High Speed Repetitive Operation.

Patch Panel Switch . . . controls the motor which engages and disengages the patch panel, insuring alignment and positive insertion.

Overload Indicator Panel . . . immediately identifies any amplifier that is in an overload condition.

Power Switch . . . allows control of primary power to computer by push-button.



Electronic Digital Voltmeter

A digital voltmeter is provided on the TR-48 Control Panel for precise, rapid digital readout of computing voltages. Completely transistorized, it offers the maximum in reliability. Its instantaneous operation and extremely high input impedance permit direct potentiometer set up with instantaneous readout of coefficient settings, as well as general readout of problem variables.

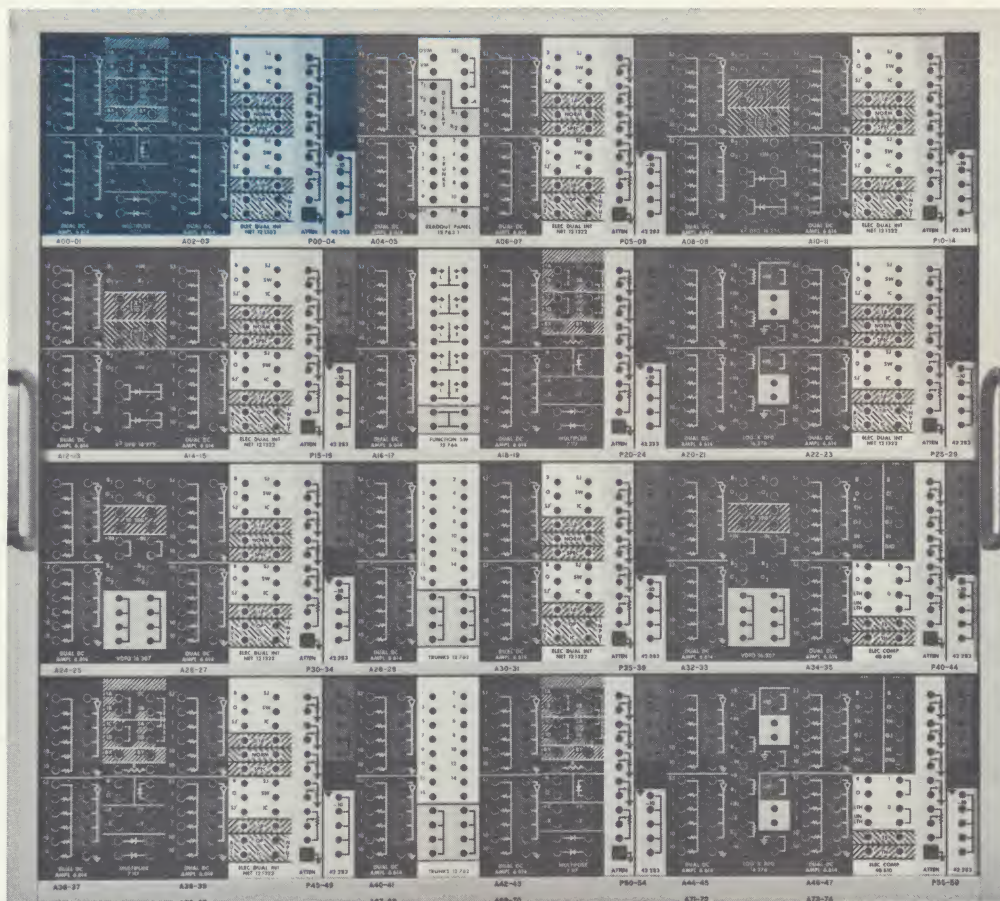
Choice of:

■ **4-DIGIT DISPLAY** . . . provides for automatic readings and polarity from 10 millivolts to ± 11.99 volts DC with fixed decimal point. (Accuracy $\pm 0.1\%$ $\pm$ One Digit)

■ **5-DIGIT DISPLAY** . . . provides for automatic readings and polarity from 1 millivolt to ± 11.999 volts DC with fixed decimal point. (Accuracy $\pm 0.01\%$ $\pm$ One Digit)

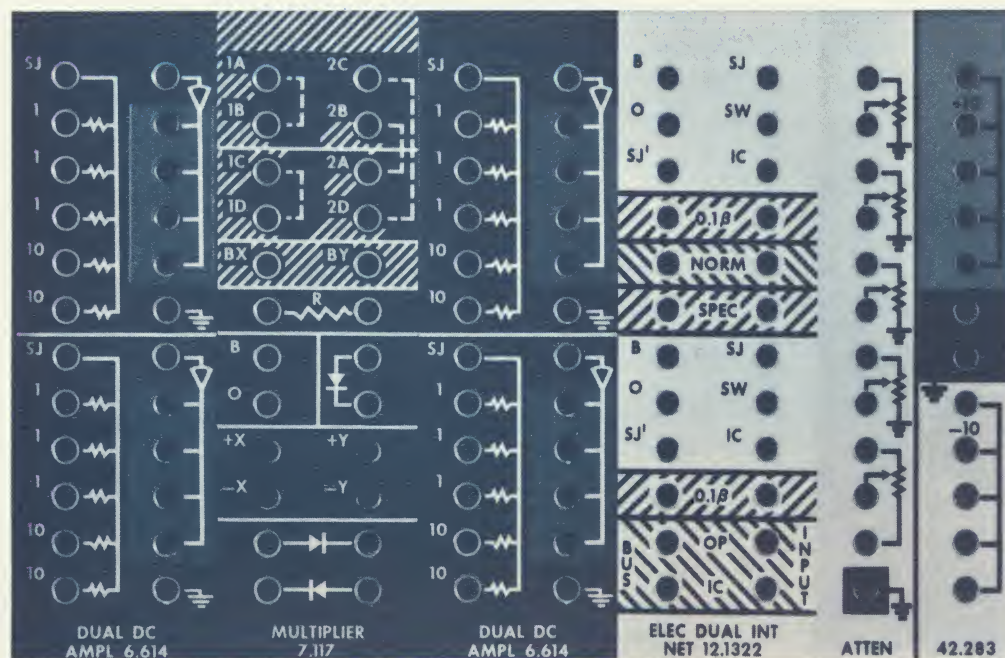
TR-48

modular patch panel simplifies programming



TR-48

interchangeable, plug-in components make expansion easy



OPERATIONAL AMPLIFIERS

The first and third positions in the module are each wired to accept a plug-in dual operational amplifier unit. These amplifiers are basic to the performance of all mathematical operations available in the TR-48. With companion precision resistor networks terminated on the same patching block, they are used for addition, subtraction, and sign inversion. Integration is performed by patching an operational amplifier to an appropriate integrator network, located in the fourth position of the module. "High-gain" operational amplifiers are also utilized as output and feedback devices to perform multiplication, division, and function generation. All amplifiers are "uncommitted" — i.e., can be used in any mode of operation.

NON-LINEAR COMPONENTS

The second position within each modular grouping of components is wired to accept a variety of non-linear computing components. The standard TR-48 is pre-wired to accept the following interchangeable components in this position: a Multiplier, a Variable DFG (5 selected positions), a Fixed DFG (Log x , $\frac{1}{2}$ Log x , or x^2), or a Dual Integrator Network. In

addition, this position (in the middle column of the functional area groupings) will accept the Type 2.462 Function Switch Group, the Type 12.763 Readout patching Unit, and the Type 2.426 Trunk Group, or the DES-30 Slaving Group.

INTEGRATOR NETWORKS

The fourth position in the module accepts a Dual Integrator Network, which contains the precision feedback capacitors for use with a high-gain amplifier to perform the operation of integration with respect to time. The position is also wired to accept all non-linear components (including the Type 40.404 comparator), except Variable DFG's.

COEFFICIENT SETTING POTENTIOMETERS

Position five in the modular group is wired to accept the 16.318 Limiter module or the 42.283 Readout module for the 2.440 Coefficient Setting Potentiometer Group. Either module provides connections to five 10 turn potentiometers used for setting equation coefficients, problem parameters, initial conditions, boundary values and problem inputs. There are four grounded and one ungrounded potentiometers in each group.

TR-48

ideal for high speed repetitive and iterative operations

The High Speed Repetitive Operation Group permits the PACE TR-48 to be operated alternately as a real time or high speed repetitive computing device. The wide bandwidth of the TR-48 solid-state computing components is utilized to produce problem solutions many times each second . . . yet there is no loss in time computing accuracy.

These outstanding features of the HSRO Group add to the problem solving capabilities of the TR-48.

- Instantaneous change from real time or repetitive operation . . . requires no repatching or reprogramming . . . allows immediate, permanent recording of selected solutions.
- Operation with either relay mode control or ultra high speed electronic mode control.
- Computing times of from 20 to 500 milliseconds per solution.
- Switched control of solution times at fixed values of 20, 50, 100 and 200 milliseconds per solution
- Continuous control of solution times between the fixed values.
- All solid-state timing unit.
- Precision polystyrene feedback capacitors.
- SLAVE feature for control of two or more real time or repetitive operated TR-48 Computers.

Repetitive operation is obtained by switching the Mode switch on the Control Panel to the Rep. Op. position . . . this automatically changes the feedback capacitors in the integrator network so as to increase the time scale by a factor of 500. The Compute Time switch is then used to select the desired rate of repetitive operation. Voltage signals generated by the REP. OP. Timing Unit operates the high speed electro-mechanical relays or solid-state switches in each Integrator Network to cycle the computer between the reset and operate modes. Energizing the RESET mode push-button stops the repetitive operation. Since each integrator is capable of individual mode control, parts of the computer may be run in "real time", while other parts operate repetitively. In addition, "multiple-speed" operation may be accomplished, if desired. Thus high-speed "iterative type" solutions may be achieved if required in a given problem.

In Repetitive Operation, the Computer Is Continuously Cycled Between the Reset and Compute Mode of Operation. The Problem Is, Therefore, Solved Repeatedly at Some Predetermined Repetition Rate, Usually Often Enough to Allow Its Presentation on an Oscilloscope.



TYPICAL USES OF HIGH SPEED REP. OP.

System Optimization . . . the selection of parameter values which give the best over-all performance.

Boundary Value Problems . . . the solution of differential equations in which the problem is to find the initial conditions for specified solutions of the equations.

Model Building . . . the problem of determining a mathematical representation for a system of known response.

Other Uses . . . rapid exploratory studies to conserve computing time . . . rapid approximation of optimum system parameters and determination of stability regions of control systems . . . approximate computation and display of integral transforms, such as Fourier integrals, superposition integrals, and correlation functions . . . statistical studies requiring many solutions . . . plus a wide variety of routine computational problems requiring numerous solutions.

Users of the PACE TR-48 Analog Computer will find the High Speed Repetitive Operation Group a valuable aid in the solution of a variety of computing problems. The higher problem solution rates make it possible to instantaneously view the effect of varying the parameters of a problem. This unique ability provides a powerful and economical computational tool for solving those problems requiring multiple solutions of the problem equations.

TR-48

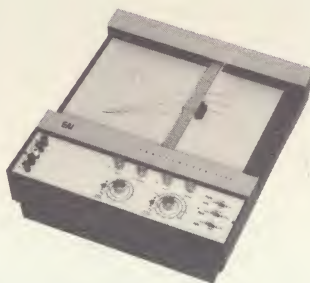
readout and display

The man-machine communication involving the display and documentation of problem results has been another area of particular emphasis in the design of the EAI TR-48 Computing System. Recognizing the need not only for the 'availability' of results but also for their accurate and reliable presentation, EAI offers a complete selection of equipment to satisfy these requirements.

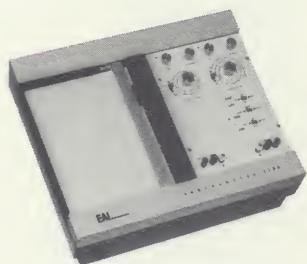
The readout system of the EAI TR-48 System utilizes a high-speed, solid-state digital voltmeter and also has provisions for a variety of peripheral devices:



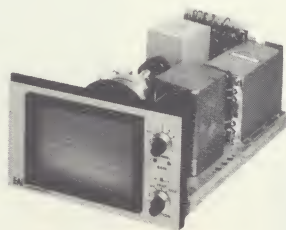
EAI 1110



EAI 1130



EAI 1120



EAI Type 2.529

X-Y RECORDERS:

The EAI 1110 transistorized 11" x 17" X-Y Recorder plots one or more independent variables as functions of time or any other independent variable — provides accurate graphic recording of computer solutions . . . has continuously variable scale factor control, pen and arm origin can be set anywhere on plotting surface, pen lift can be controlled by computer mode control system, scale extension or suppression permits plotting in any desired quadrant within a 30" x 45" area.

The EAI 1130 transistorized 11" x 17" X-Y Recorder is a general-purpose instrument offering somewhat lower accuracy than the 1110. A built-in time-base eliminates the need for generating a ramp on the computer, when the lower time-base accuracy of the recorder will suffice. Output may be patched directly from the computer to the front panel terminals of the recorder. An optional remote data connector is available for remote pen lift control and termination of the recorder inputs at the computer readout module.

The EAI 1120 transistorized 8½" x 11" X-Y Recorder is also available for use with the TR-48. It offers an economical means of obtaining an X-Y recorder, and it is identical to the 1130 in operation, except for its smaller plotting surface.

MULTI-CHANNEL HIGH-SPEED REPETITIVE OPERATION DISPLAY UNIT:

The EAI Type 2.529 Display Unit is a self-contained precision display system which installs in the TR-48 computer above the control panel. Employing an 8-inch oscilloscope, this unit provides simultaneous display of four traces and requires the setting of only three operator controls . . . intensity, position, and number of traces. Sweep speed is automatically controlled by the repetitive operation timer of the computer, or the operator may cross plot three input channels against the fourth.

The digital voltmeter and Display Scope are conveniently terminated on the patch panel readout module, next to the output of the push-button select system. X-Y recorders may be connected through rear data connectors on the computer, which terminate on the patch panel.

TR-48

transistorized dc operational amplifiers . . . the basic building block of the TR-48

DUAL AMPLIFIER MODULE 6.614

The heart of the TR-48 is the transistorized DC operational amplifier. By connecting various input or feedback networks to the operational amplifier specific mathematical operations are obtained.

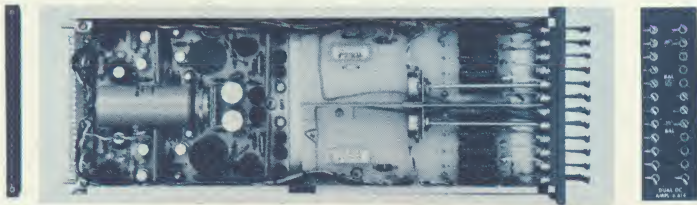
The TR-48 Computer employs identical, interchangeable amplifier modules each consisting of two transistorized DC amplifiers, terminated on the patch panel as high-gain amplifiers. Companion networks, consisting of input and feedback resistors matched to 0.01% accuracy, are conveniently terminated in the module for converting each amplifier to inverter or summer operation by convenient bottle plugs.

QUAD AMPLIFIER 6.704

Provides four independent operational amplifiers in one plug in module which fits in the place of a dual amplifier.

SIMPLIFIED PATCHING

Operational amplifiers in the TR-48 are terminated with companion precision input and feedback resistors. Insertion of a 4-prong bottle plug into the top four holes of the amplifier patching block connects a feedback resistor across the amplifier and the common connection of the input resistors (Summing Junction) to the amplifier base. The amplifier thus functions as a summer with two gain-of-1 and two gain-of-10 inputs. Additional inputs may be connected to the summing junction termination available on the back of the bottle plug. Omission of the 4-prong bottle plug makes the amplifier available as a high gain amplifier for connection to integrator networks or non-linear components.



Note: The illustration above shows a typical module including the patch block which mounts in the pre-patch panel. Installation of modules and patch blocks are illustrated on the following page.

Superior performance characteristics . . . low temperature drift . . . low offset . . . low noise . . . extended usable frequency response.

Completely transistorized . . . for increased reliability . . . backed by the enviable performance record of thousands of similar units operating in the field.

Chopper stabilized . . . each computing amplifier is individually and automatically stabilized to reduce offset and drift to a minimum.

Individual balance adjustment . . . provided on every operational amplifier.

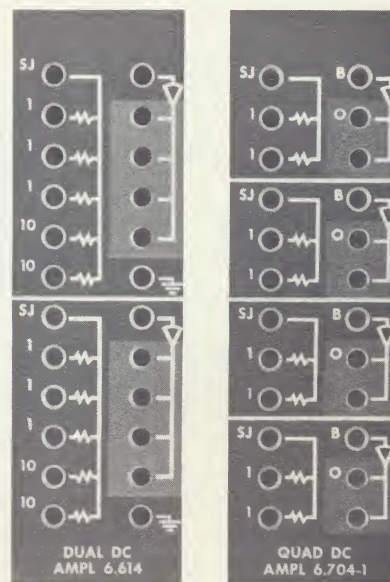
Single-ended input and output . . . emitter-follower bridge output circuit assures linear operation with low output impedance . . . low-current emitter-follower input stage insures high input impedance for excellent drift characteristics.

Up to 58 Amplifiers in TR-48

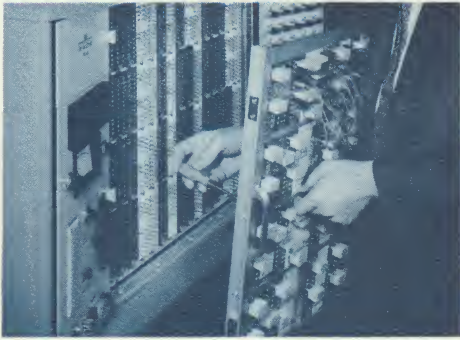
The addition of a simple harness allows up to five quad amplifiers to be used in the bottom patch panel row in place of five dual amplifiers.

Uncommitted

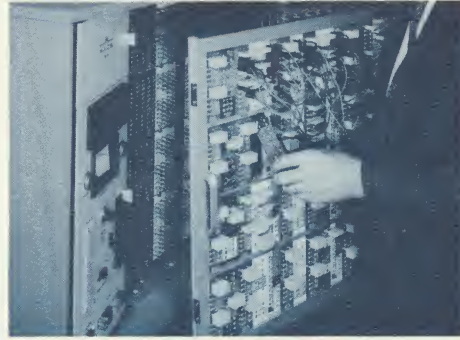
Although primarily designed to be used with non-linear equipment, the 6.704 quad amplifiers can be used as summing or integrating amplifiers. A 100k input and a 100k feedback resistor are supplied within the plug-in module for each amplifier. This allows easy patching as inverter amplifiers.



changing the equipment complement is easy with the TR-48



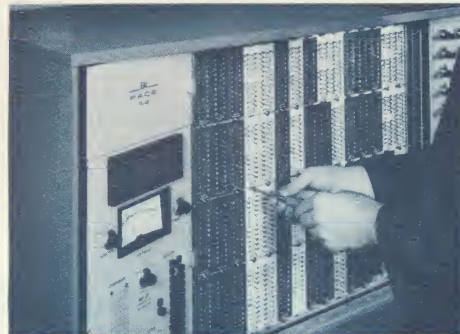
Loosen the pre-patch panel retaining frame. 1.



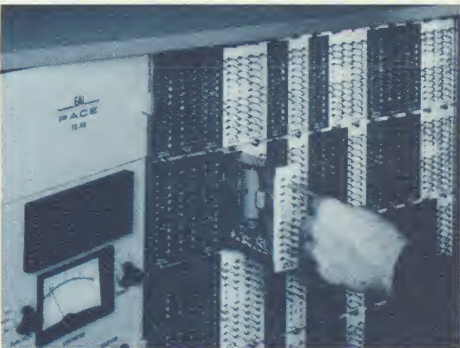
Snap out the patching block of the component to be replaced and replace it with a block for the desired component. 2.



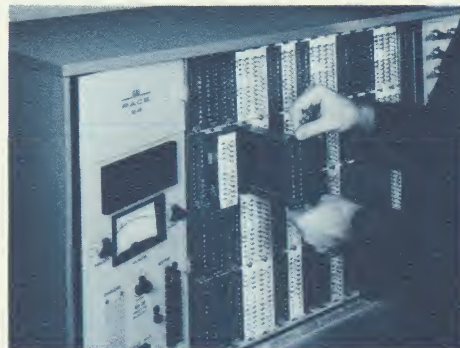
Tighten the pre-patch panel retaining frame. 3.



At the front of the computer and with the pre-patch panel removed loosen the two retaining fasteners which secure the component to be replaced. 4.



Pull the component out of the computer. 5.



Plug the desired component into the empty position. No re-wiring is necessary. 6.

TR-48

individual component descriptions

All modules described on the following pages consist of a component tray and pre-patch panel block. The illustrations show only front views of the patch panel blocks, since the component trays are similar to the one illustrated on the previous pages.

DUAL INTEGRATOR NETWORKS

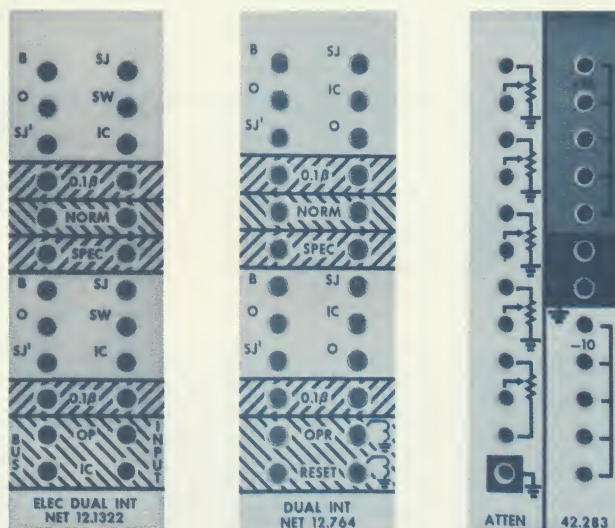
- Consists of two networks, each containing the precision capacitors that enable any high gain amplifier to be connected to perform the mathematical operation of integration with respect to time.
- Simple bottle plug patching connects integrator network to adjacent high gain amplifier, thus converting it to an integrator.
- "IC" termination is available for introducing non-zero initial conditions into integrator if required. Patching remains the same for "real time" or "Rep Op" mode of operation.
- Individual integrator 10 to 1 time scale change accomplished by bottle plug patching in either real time or HSRO operation.
- Precision $\pm 0.05\%$ Polystyrene capacitors used throughout for low drift and high-dynamic accuracy.
- Patching terminations allow separate control of integrator operating mode for signal tracking and storage, permitting multi-speed and iterative operation.

Dual Integrator Network Type 12.1322 (used with Electronic Mode Control TR-48)

- OPERATE and IC modes are controlled by two logic level operated electronic switches.
- HOLD mode is made available through the use of an internal relay.
- If integration is not required electronic switches may be used for switching analog voltages.
- Mode control of integrators may be operated from main computer mode busses or from logic output of logic devices such as electronic comparators.
- Energizing the "SW" termination with a logic level 0 converts the integrator into a single pole double throw switch.

Dual Integrator Network Type 12.764 (used with Relay Mode Control TR-48)

- Contains all relays necessary for switching the integrator to RESET, HOLD, OPERATE modes of operation. Relay operation is controlled by computer mode push buttons on control panel.

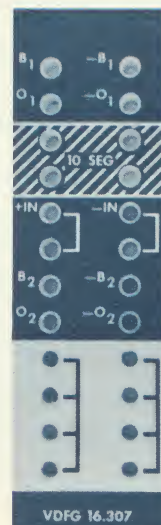
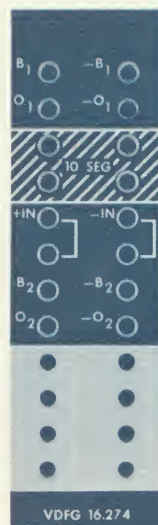
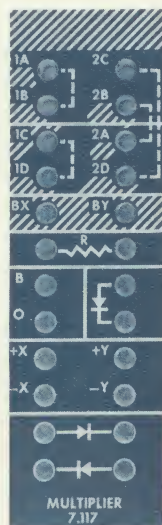
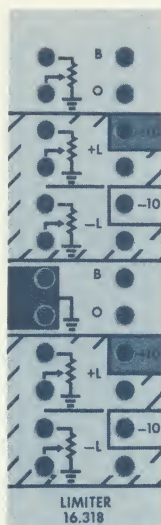


COEFFICIENT SETTING POTENTIOMETER GROUP (Type 42.283)

- Used for setting problem coefficients, initial and boundary conditions, as well as problem inputs.
- Each group provides five potentiometers mounted in the potentiometer area on the right-front of the TR-48, as well as suitable patch panel terminations for their connection into problem circuits.
- Consists of ten-turn, wire-wound, 5,000 ohm potentiometers individually fused and equipped with calibrated adjustment knobs.
- The top and arm of four potentiometers in the group are terminated on the patch panel with their bottom ends internally grounded. The fifth potentiometer is terminated with top, bottom, and arm available at the patch panel.
- Potentiometer patching area includes plus and minus 10 volt reference terminations and convenient ground terminations for grounding ungrounded potentiometers.
- Potentiometer setting has been made extremely simple for the operator. The computer is placed in the "Pot Set" mode and the pot to be set selected on the readout panel. The Coefficient Setting then appears on the digital voltmeter and the potentiometer is adjusted as desired.

DUAL LIMITER (Type 16.318)

- Used to limit amplifier output at a predetermined value set on a potentiometer.
- Each limiter has separately adjustable positive and negative limits.
- Utilizes standard coefficient potentiometers for setting limits.
- Fits in any readout position normally occupied by attenuator readout module 42.283.
- Allows normal use of potentiometers when not used to set limit values.



MULTIPLIERS (Types 7.099 and 7.117)

A completely solid-state device which makes use of the quarter-square technique of multiplication to produce, when used in conjunction with a high-gain amplifier, a product of two input variables of either polarity. The mathematical operations of division, squaring, and square root may also be performed.

Solid-state reliability . . . silicon diodes and ultra-stable resistors are used throughout to minimize drift and insure long, maintenance-free life.

Wide computing bandwidth . . . dynamic performance unsurpassed by any other type of continuous multiplication device — bandwidth compatible with the wide bandwidth of the amplifier.

Low noise . . . and infinite resolution result from the elimination of servo potentiometers and time division oscillators.

Four Quadrant multiplication . . . when used in association with a transistorized DC amplifier the product $-XY/10$ is produced from inputs $+X$, $-X$, $+Y$ and $-Y$. Output polarity may be easily reversed by interchanging $+X$ and $-X$ or $+Y$ and $-Y$ input connections.

Plug-in design . . . can be plugged into any non-linear or integrator network position — permits rapid replacement for servicing and interchanging of components.

Simplified patching . . . clearly marked patching terminations simplify interconnection between other components. Bottle-plug connections place the multiplier in the "multiply", "divide", "square", or "square-root" mode of operation.

Square - Square Root . . . multipliers may be patched to provide two independent square and square root functions per multiplier.

Division . . . simple patching provides division of two variables.

VARIABLE DIODE FUNCTION GENERATORS . . .

Completely solid state components are used to generate an arbitrary function of an input voltage X . The representation is made through the use of many straight line segments.

10/19 Segment Operation . . . VDFG may be used individually for single polarity input or combined for 19 segment function generator for input signals of both polarities.

DFG Operation utilizes external high gain operational amplifiers . . . two required for each 10 segment generator or for a single 19 segment combination.

Function Set-up to produce a desired function is made by a quick screwdriver adjustment.

DFG Chassis is mounted in area behind TR-48 potentiometer panel. Units slide out for ease of set-up.

DFG Patching Module mounts behind the patch panel in a variety of selected non-linear positions.

Fixed Breakpoint Generators (2.488 Groups)

Type 16.274 Readout Module

Type 16.154-2 — Accepts input voltages ranging from 0 to -10 Volts. Ten straight line segments are used to represent the desired function. Nine adjustable slope potentiometers and one zero slope potentiometer are provided.

Type 16.156-2 — The same as 16.154 except input voltage is 0 to $+10$ Volts.

Variable Breakpoint Generators (2.638 Groups)

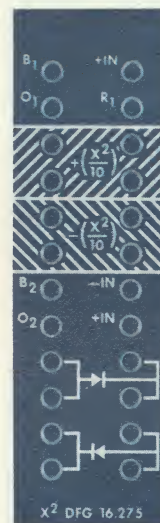
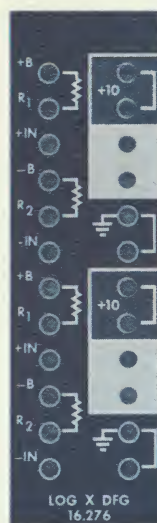
Type 16.307 Readout Module

Type 16.304-2 — Accepts input voltages ranging from 0 to $+10$ Volts. Ten adjustable slope potentiometers and ten adjustable breakpoint potentiometers are provided. Central slope and parallax potentiometers are also provided.

Type 16.306-2 — The same as 16.304-2 except input voltage range is 0 to -10 Volts.

TR-48

individual component descriptions



FIXED FUNCTION GENERATORS

Log Diode Function Generator (Types 16.276 and 16.281)

Log function generators are extremely valuable in a general purpose simulation for raising a variable to an unusual power (i.e., 1.8, 2.6 etc.) or a variable power (i.e., X^y). They are also useful for multiplication, division, squaring, square-rooting, etc. as alternates for multipliers or other function generators. The Type 16.276 and 16.281 Log Generators have the following characteristics:

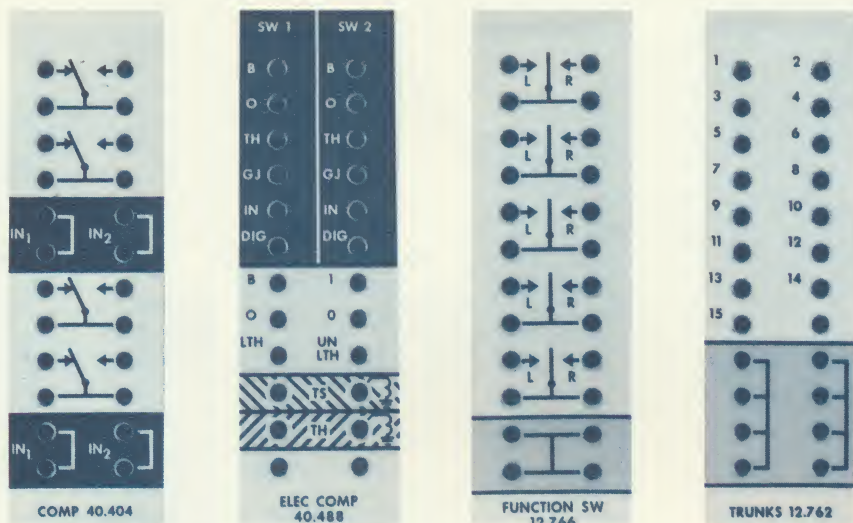
- Dual fixed diode function generators composed of completely solid-state components.
- Two types available:
 1. Type 16.276 produces an output of $5 \log_{10}(10X)$ for an X input.
 2. Type 16.281 produces an output of $2.5 \log_{10}(10X)$ for an X input.
- When operated in combination with an external high-gain, transistorized operational amplifier, each type of Log DFG is capable of the following operation:
 - A. Output of $\log_{10}$ for an X input of one polarity.
 - B. Output of $\log_{10}X_1$ and $\log_{10}X_2$ when inputs X_1 and X_2 are unipolar and of opposite sign (two amplifiers required).
 - C. An exponential output when the Log DFG is used in feedback of high-gain amplifier.
- Utilizes seven (7) straight line segments to approximate a logarithmic curve for a single sign of input voltage.
- Accepts inputs in the range ± 10 volts DC; provides outputs in the range of ± 10 volts DC depending upon connections.
- Mounts in any non-linear or integrator network position.

Dual X^2 Diode Function Generator (Type 16.275)

- A dual fixed diode function generator composed of completely solid-state components.
- One dual chassis is capable of the following operations:
 - A. When operated in combination with an operational amplifier it will yield an X^2 output for an X input of one polarity.
 - B. When operated in combination with two operational amplifiers it will deliver outputs of $(X_1)^2$ and $(X_2)^2$ when both X_1 and X_2 are unipolar and of opposite sign.
 - C. When operating in combination with two operational amplifiers it will deliver an output of X^2 with the input X varying both plus and minus in sign.
 - D. A square root output may be obtained by using the X^2 DFG in the feedback of an operational amplifier.
- Accepts inputs to ± 10 volts, provides outputs of ± 10 volts.
- Fully electronic to provide wide computing bandwidth.

Sine-Cosine Generator (Type 16.314)

- Used in conjunction with two operational amplifiers, generator accept inputs ranging from $-10V$ to $+10V$ and provide outputs in all four quadrants ($\pm 180^\circ$) for sine and cosine.
- Correct magnitude of scaling is automatically insured.
- Direct conversion from angular input to sine and cosine output using generator and operational amplifiers.
- Forward and Inverse resolution when used with auxiliary quarter square multipliers.



COMPARATORS

Comparator (Type 40.404)

- Compares a variable input voltage to an arbitrary bias voltage and causes a switching operation to be performed; very useful for "decision making" operations within the computer program.
- Consists of a three-stage, transistor amplifier and a high-speed, double-pole-throw relay.
- When the algebraic sum of input variable and bias voltage is positive, the relay will assume one position and, when this sum is negative, it will assume the other.
- Two comparators mounted in a single plug-in unit . . . can be placed in any non-linear position.

Electronic Comparator (Type 40.488 for relay mode control computers)

- Contains two solid state sections; a comparator section and an electronic switch section. Each section utilizes an external operational amplifier.
- Comparator section gives a logic output signal when the algebraic sum of the input signal and the reference voltage is positive.
- Switch section is used to switch one of two signals into associated operational amplifier.
- Comparator logic output may be used to operate switch section or operate other logic devices.
- Switch section may be operated from logic signals other than from comparator section.
- Special "latch" and "unlatch" inputs allow control of comparator during complex operations.
- Module also contains components and patching terminations needed to perform "track" and "hold" modes during both real time and repetitive operation.

Electronic Comparator (Type 40.610 for electronic mode control comparators — not illustrated)

- Identical to the Type 40.488 in operating functions.
- Provides correct mode control voltage levels for Electronic Mode Control Comparators.

FUNCTION SWITCH GROUP (Type 2.462)

- Provides five independent, single-pole, double-throw, center-off, function switches for performing manual switching operations.
- Function switches mount in lower portion of Coefficient Setting Potentiometer panel.
- Function switch patching Module type 12.766 mounts in any one of three lower integrator Network positions in middle column of component modular groupings.
- Switch contacts are rated at 120 volts, 1.0 amperes resistive load.

TRUNK MODULE (Type 12.762)

- Used for connection of problem signal voltages between two TR-48 Computers operated in parallel, or for connection of computer to external hardware or instrumentation.
- Provides 15 patch panel terminations for rear connected inter-console trunking cables.
- Patching area mounts in integrator network position in any one of three lower rows of the middle column of component modular groupings.

TRUNK GROUP (Type 2.426)

- Provides 15 trunks between two TR-48 computers. Consists of:
 - 2 ea. Type 12.762 Trunk Modules
 - 1 ea. Type 19.261 Cable

TR-48

individual component descriptions

READOUT MODULE

- Standard on all TR-48's.
- Provides patch panel terminations for accessory recording equipment cabled to rear of TR-48 Computer.
- Terminations provided are:
 - A. X and Y inputs for X-Y Recorder, as well as "automatic pen lift" control of recorder.
 - B. Inputs for two 4-channel time base recorders or one 8-channel recorder, or 10 Trunks, as required.
 - C. X and Y inputs for oscilloscope.
 - D. Output of signal select system and inputs to digital voltmeter and voltmeter.
 - E. Output of the Reset (RS or IC) Buss Mode and the mode control voltage.

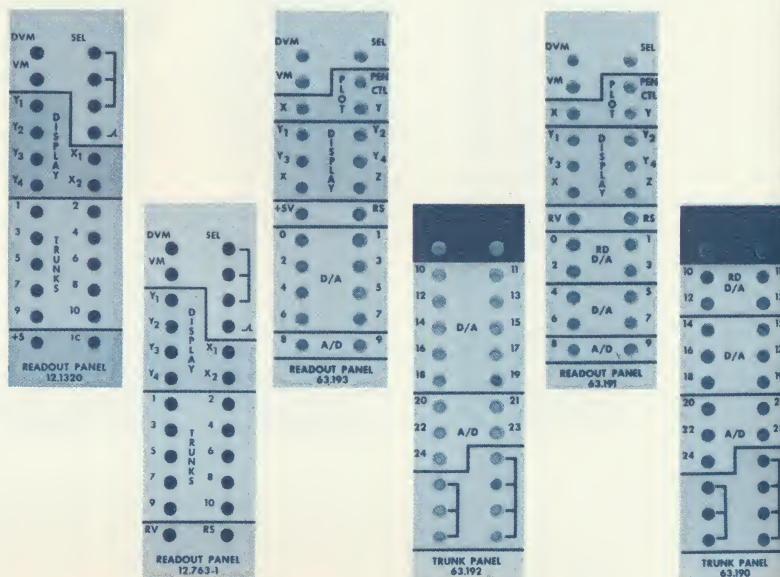
Readout Module Type 12.1320 (used with electronic mode control TR-48)

Readout Module Type 12.763-1 (used with relay mode control TR-48)

READOUT AND INTERFACE WITH DES-30 — Special readout modules are required, when using the TR-48 in conjunction with the DES-30. These modules contain control, D/A, and A/D trunks in place of the normal analog trunks.

Readout/Logic Slave Tray Module Type 63.193 (used with electronic mode control TR-48). This module has sufficient trunks for interface with basic and standard DES-30's. An expanded interface adds the Logic Trunk Tray Type 63.192, which provides additional A/D and D/A trunks for the expanded DES-30.

Readout/Logic Slave Tray Module Type 63.191 (used with relay mode control TR-48). This module has sufficient trunks for interface with basic and standard DES-30's. An expanded interface adds the Logic Trunk Tray Type 63.190, which provides additional A/D and D/A trunks for the expanded DES-30.



ACCESSORIES

- **Bottle Plugs**
 - Type 5.173 - 6-prong "T" for connecting Integrator Network to adjacent high gain amplifier.
 - Type 5.172 - 4-prong for converting high gain amplifier to inverter or summer operation.
 - Type 5.174 - 2-prong-horizontal for connecting adjacent horizontal terminations.
- **Multiple Block (Type 542.605)**
 - Provides a 6-hole, off-the-patch-panel tie point for interconnecting patch cords or increasing the number of output holes of computing components.
- **Patching Kit (Type 5.171)** includes the following:
 - 20 each patch cords Type 510.043-0, 6" long; Color: Black
 - 30 each patch cords Type 510.043-1, 12" long; Color: Brown
 - 20 each patch cords Type 510.043-2, 18" long; Color: Orange
 - 10 each patch cords Type 510.043-3, 30" long; Color: Blue
 - 30 each bottle plugs Type 5.174
 - 32 each bottle plugs Type 5.172
 - 8 each bottle plugs Type 5.173
 - 2 each Multiple Blocks, Type 542.605
- **Service Shelf (Type 51.116)** permits convenient maintenance of computing components under normal operating conditions.
- **Slave Cable (Type 19.262)** only accessory needed to slave two TR-48's.
- **Junction Box (Type 47.040)** used with slave cables to slave up to six TR-48 computers.

DIGITAL EXPANSION SYSTEM, DES-30

The DES-30 is a low cost digital logic expansion to the TR-48. It provides hybrid capability to the desk top computer user. In combination with the TR-48, the DES-30 enables the solution of problems far more complex than previously possible with computers of the TR-48 size.

- **Synchronous Logic** . . . logic operations are timed from internal clock or may be triggered by an external signal.
- **Removable Patch Panel** . . . Allows the storage of logic routines. Panel is clearly marked with logic symbols. Special "piggy back" patch cords are used for easy patching.
- **Easily Expanded** . . . All components are modular plug-in units allowing fast expansion. Basic frame is completely wired for full expansion capability.
- **Self Contained** . . . Unit supplies its own power.
- **Logic Indicator Field** . . . Contains a logic state indicator for each logic storage element in the DES-30.
- **Easy System Check** . . . Logic may be manually stepped for ease of program checkout.
- **Multitude of Plug-in Modules** . . . gates, flip flops, registers, counters, monostables, etc.

Request Bulletin 65011-1 for detailed information on the DES-30.

SLAVING COMPUTERS

Two or more TR-48's may be slaved together and/or to TR-20 computers, to provide sufficient capacity to solve complex system design problems. The TR-48 is designed to be slaved; all the required circuitry is standard on every machine. The interconnection of machines with a slave cable is all that is required to obtain mode control slaving, reference slaving, and ten trunk lines. Additional trunk lines may be provided by using trunking modules and a trunk cable.

The digital voltmeter in one TR-48 may be used to set potentiometers and readout voltages in another TR-48.

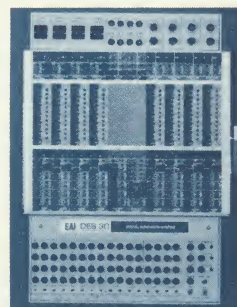
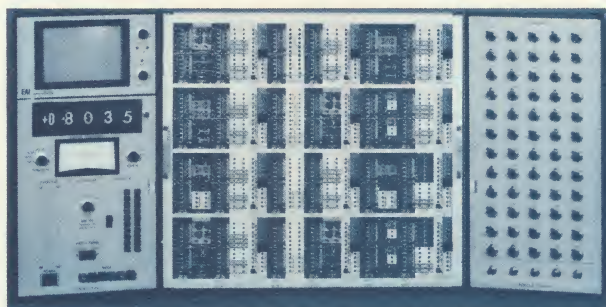
Slaved machines may be quickly disconnected to permit the solution of two or more individual problems simultaneously.

PHYSICAL DESCRIPTION TR-48

Width 48 inches
Height 25 inches
Depth 20 $\frac{1}{4}$ inches
Weight . . . 320 lbs., approx. (fully expanded)
Power Source . . 115/230 volts, 50-60 cycle
Power Requirement under 150 watts
(fully expanded)

PHYSICAL DESCRIPTION DES-30

Width 20 $\frac{1}{2}$ inches
Height 25 inches
Depth 20 $\frac{1}{4}$ inches
Weight (fully expanded) 175 lbs
Power Source . . 115/220 volts, 50-60 cycle
Power Requirement 125 watts
(fully expanded)



TR-48

can be ordered with the component complement to satisfy individual requirements

Basic TR-48-0

The TR-48-0 is a minimum linear computer available to the user desiring to acquire his initial computing capability at minimum cost. The TR-48-0 has all of the precision features of the expanded models and may be used in the simulation of small linear systems. It may be readily expanded up to the full 58 amplifier size.

Basic TR-48-1

The TR-48-1 provides for more extended linear simulation than the TR-48-0, but is still designed for the laboratory desiring a reliable and expandable analog computer — at a modest initial investment. The TR-48-1 is capable of solving a variety of linear engineering problems, and as your problems become more complex, your TR-48-1 may be easily expanded.

Expanded TR-48-2

The TR-48-2 contains a somewhat larger complement of linear equipment, as well as a variety of non-linear computing elements. Its expanded total capacity makes it ideally suited for the simulation of complex linear and non-linear systems.

Expanded TR-48-3

The TR-48-3 represents the computer in an expanded form. Highly complex and non-linear simulations may be accomplished on this machine. The complement of equipment within the TR-48-3 is extremely varied and versatile and will satisfy the needs of the typical design engineering activity.

RECOMMENDED COMPUTER SIZES

Equipment	TR-48			
	—0	—1	—2	—3
Pre-wire Console	1	1	1	1
Push-button Readout System . .	1	1	1	1
Electronic Digital Voltmeter . .	—	1	1	1
Multi-Range Voltmeter	1	1	1	1
Null Potentiometer	1	0	0	0
Reference System	1	1	1	1
Power Supply	1	1	1	1
Overload Indicator Panel	1	1	1	1
Service Shelf	1	1	1	1
Repetitive Operation Group . . .	—	1	1	1
Operational Amplifiers	10	20	32	48
Coefficient Setting				
Potentiometers	10	20	40	60
Integrator Networks	4	8	12	16
Multipliers	—	—	3	5
Variable DFG Cards*	—	—	4	6
Log X DFG Cards*	—	—	—	4
X ² DFG Cards*	—	—	—	2
Comparators	—	—	2	4
Limiters	—	—	2	4
Function Switches	—	—	5	5
External Trunks	—	—	15	30
Readout Patching Module	1	1	1	1
Patch Panel	1	1	1	1
Patching Kits	1	1	2	2

Expanded TR-48-3 plus spare non-linear components

□ Effectively provides several computers in one console. By purchasing additional interchangeable non-linear components, beyond the maximum capacity, you can achieve unusual computing flexibility.

Other TR-48 Expansions . . . than those recommended above are readily accomplished by simply plugging in the desired number and type of computing components . . . power voltages, monitoring and control facilities for a fully expanded computer are incorporated in the Basic Computer — no additional wiring necessary.

*Half the cards accept plus voltage, the other half minus voltage.



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ELECTRONIC ASSOCIATES, INC. *West Long Branch, New Jersey*

ADVANCED SYSTEMS ANALYSIS AND COMPUTATION SERVICES/ANALOG COMPUTERS/DIGITAL COMPUTERS/HYBRID ANALOG-DIGITAL COMPUTATION EQUIPMENT/ANALOG AND DIGITAL PLOTTERS/SIMULATION SYSTEMS/SCIENTIFIC AND LABORATORY INSTRUMENTS/INDUSTRIAL PROCESS CONTROL SYSTEMS/PHOTOGRAMMETRIC EQUIPMENT/RANGE INSTRUMENTATION SYSTEMS/TEST AND CHECK-OUT SYSTEMS/MILITARY AND INDUSTRIAL RESEARCH AND DEVELOPMENT SERVICES/FIELD ENGINEERING AND EQUIPMENT MAINTENANCE SERVICES.

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